

EFFECT OF BIOPESTICIDES ON MAJOR INSECT PESTS, NATURAL ENEMIES AND YIELD OF CABBAGE

ABSTRACT

Aims: This study is aimed to know the effect of biopesticides on insect pests, predators and yield of cabbage.

Study Design: The experiment was laid out at a randomized complete block design with four replications.

Place and Duration of Study: Central farm of Sher-e-Bangla Agricultural University, Bangladesh during the period from October 2018 to March 2019.

Methodology: Six treatments were used in this experiment which were T₁= Spinosad, T₂= SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃= Spodolure trap, T₄= Spodolure trap + Spinosad spray, T₅= Spodolure trap + SNPV spray and T₆= untreated control.

Results: Results revealed that the lowest number of infested leaves by flea beetle (0.33/ 5 plants), tobacco cutworm (0.33/ 5 plants), semi- looper (0.33/ 5 plants), diamondback moth (1.33/ 5 plants), aphid (7.50/ 5 plants), was found in T₄ treatment (Spodolure trap + Spinosad). In case of incidence of natural enemies, the highest number of lady bird beetle (8.00/plot) and spider (8.60/plot) was also found from T₄ (Spodolure trap + Spinosad) treatment compared to untreated control. The highest percentage of healthy plants (91.67%), highest weight of healthy cabbage head plant⁻¹ (1.20 kg), marketable cabbage head plot⁻¹ (19.48 kg) and marketable yield of healthy cabbage head (45.08 t ha⁻¹) was found in T₄ (Spodolure trap + Spinosad) treatment.

Conclusion: It is concluded that Spodolure trap in combination with Spinosad spray may be effective practice for the management of cabbage insect pests.

Keywords: Cabbage; Predators ; Spodolure ; Spider; SNPV; Marketable yield.

1. INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) is an important vegetable crop which is extensively cultivated because of its economical and nutritional values from the producers and consumers point of view respectively [1]. In 2015-2016, 237 thousand metric tons of cabbage was produced [2]. The yield produced by cabbage in Bangladesh is 75-100 ton/ha depending on selection of variety and season [3]. These yields are low comparing with other developing countries. Various reasons are responsible for low yield of cabbage. Insect pest infestation and lack of proper management of insect pest is one of the main reasons for low yield of cabbage.

Cabbage is prone to insect pest ravages from the time of sowing till the harvest. The crop is attacked by a number of insect pests, viz. tobacco caterpillar, *Spodoptera litura* (Fab.); diamond back moth, *Plutella xylostella* (L.); cabbage leaf webber, *Crociodolomia bionotalis* (Zell.); aphids, *Bravicornye brassicae* (L.) and *Lipaphis erysimi* (Kalt.); painted bug, *Bagrada cruciferarum* (Kirk.) and flea beetle, *Phyllotreta cruciferae* (Goeze.) etc. [4]. Among various insect pests attacking cabbage, some of them are very serious like diamond back moth, *P. xylostella* (L.) causes significant losses. Diamondback moth (*Plutella xylostella* L.) is reported as a primary pest that causes heavy loss of the cabbage field by larval feeding [5]. Yield loss due to the attack of *P. xylostella* on cabbage was reported 44.6 and 53 percent respectively [6] [7]. Tobacco caterpillar (*Spodoptera litura* Fab.) is one of the important insect pests of crops in the Asian tropics and the pest was found to occur in cabbage growing areas

[8]. It can reduce more than 50% yield in some cabbage genotypes [9]. The caterpillars of semi-looper feed voraciously and cause large damage by making holes on the cabbage head [10]. They deposited eggs on the underside of leaves near the leaf edge. Flea beetle infestation leads to at least 25 % foliage damage characterized by “shot holes” on the foliage [11].

Pesticide use for growing vegetables was six times higher than the rice (1.12 kg/ha for vegetables, while it was only 0.20 kg/ha in rice) [12]. Conventional insecticides continue to be one of the most powerful weapons available for the control of pests, but their wide scale and indiscriminate application creates problems like, development of resistance and resurgence of pests; besides, leaving excessive residue on edible portions [13] [14].

So, eco-friendly management using bio-pesticide can be an alternative to control insect pest of cabbage as well as to keep sound environment. It has been observed that effective management of *Spodoptera litura* can be ensured with the mass trapping of *Spodoptera litura* by pheromone traps along with 2-3 application of SNPV [15]. In Bangladesh, scientists of different public research institutes and universities have already developed bio-pesticide based pest management packages against several destructive insect pests and diseases of different crops. Keeping this view in mind, the research was undertaken to test the efficacy of bio-pesticide for succession of insect pests and natural enemies in cabbage ecosystem and management of major insect pest.

2. MATERIALS AND METHODS

2.1 Experimental site

The research work was conducted during the period of October 2018 to March 2019, at the central farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The location of the site is 23^o74/N latitude and 90^o35/E longitude with an elevation of 8.2 meter from sea level.

2.2 Climate and soil

The experimental site was subtropically characterized by high temperature, high humidity and heavy rainfall in Kharif season (April to September) and scanty of rainfall in Rabi season (October to March). The soil was having a texture of silty clay with pH and organic matter 5.8 and 1.16%, respectively. The results showed that the soil composed of 27% sand, 43% silt and 30% clay [16].

2.3 Experimental treatment and design

The seeds of BARI cabbage-2 (Agradut) were used as the test crop. It is a high yielding variety with average yield 50-55 t/ha⁻¹. Nine treatments, viz. T₁ (Spinosad @ 25 ml/ha at 7 days interval), T₂ (SNPV (Spodoptera litura nuclear polyhedrosis virus) @ 2.47/ha at 7 days interval), T₃ (Spodolure @ 1/6 plot at 14 days interval), T₄ (Spodolure + Spinosad), T₅ (Spodolure + SNPV) and T₆ (Untreated Control) were used at seven days interval. We laid out the experiment in a Randomized Complete Block Design (RCBD) with four replications. The area of a single plot of the experiment was 2.4 m x 1.8 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m.

2.4 Crop husbandry

The seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. and were sown on the seedbed on October 20, 2018. Before seed sowing, the seedbed was prepared well and made suitable for seedling production. The main plot which select for conducting the experiment was opened in the last week of October, 2018 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed accordingly. The experimental main plot was partitioned into unit plots in accordance with the experimental design. Standard dosages of cowdung and fertilizers were applied as recommended by BARC Fertilizer Recommendation Guide-2018 [17]. Cowdung, urea, TSP and MoP were applied @

10000, 370, 250 and 250 kg ha⁻¹. 28 days old seedlings were transplanted in the main field on 22 November, 2018. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required. Intercultural operations such weeding, earthing up, irrigation, etc. were done as and when required for ensuring and maintaining the normal growth of crops.

2.5 Data collection

Five plants were randomly selected from each unit plot for the recording of necessary data. The data of different parameters was collected as well as recorded twice in week starting from 10 days after transplanting the seedlings from seedbed to the main field. The data on crop characters like the number of healthy and infested leaves no. of healthy and infested head, Number of insect pest plant⁻¹, the weight of individual head; height and diameter of cabbage heads; yield (t ha⁻¹) were recorded. Only the fully compact and marketable heads were harvested at the time of harvesting.

2.6 Statistical package

Collected data were analyzed following ANOVA techniques by using MSTAT computer package program. Mean values were ranked and compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance [18].

3. RESULTS AND DISCUSSION

3.1 Incidence of insect pest during cabbage cultivation

Five major insect pests named flea beetle (*Phyllotreta* spp.), aphid (*Brevicoryne brassicae*), semi-looper (*Trichoplusia* spp.), diamondback moth (*Plutella xylostella*) and tobacco cutworm (*Spodoptera litura*) were found in the cabbage field during the experimental period.

3.1.1 Incidence of cabbage flea beetle

Among the identified insect pests, flea beetle is the only insect that adult stage attacked cabbage leaves and caused damage by feeding leaf lamina in the form of small hole. Significant variation was observed on cabbage flea beetle in number among the treatments (Fig. 1). Results revealed that the lowest number of cabbage flea beetle (0.33) was found from T₄ (Spodolure + Spinosad) treatment whereas the highest number of cabbage flea beetle (5.28) was found from control treatment T₆. Under treated plot, the highest number of cabbage flea beetle (3.00) was found from T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) which was statistically identical with T₁ (Spinosad). Islam et al. 2017 reported more or less similar result in the same variety.

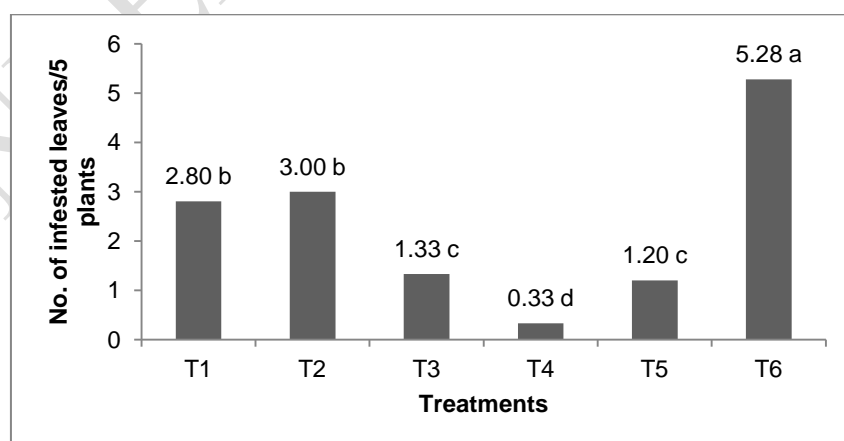


Fig.1. Incidence of flea beetle by number in cabbage field treated by different treatments

T₁ = Spinosad, T₂ = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃ = Spodolure, T₄ = Spodolure + Spinosad, T₅ = Spodolure + SNPV, T₆ = Control

3.1.2 Incidence of cabbage aphid

Aphid at its adult and nymphal stages attacked cabbage leaves and damage caused by sucking cell sap from the tender leaves resulting weaken of the plants. Significant variation was observed on Aphid incidence in number among the treatments (Fig. 2). Results revealed that the lowest number of Aphid (7.50) was found from T₄ (Spodolure + Spinosad) treatment whereas the highest number of Aphid (26.44) was found from control treatment T₆. Under treated plot, the highest number of Aphid (23.60) was found from T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) which was statistically identical with T₁ (Spinosad). Bhavani and Punnaiah (2006) also found the more or less similar result using some botanicals and biopesticides [20].

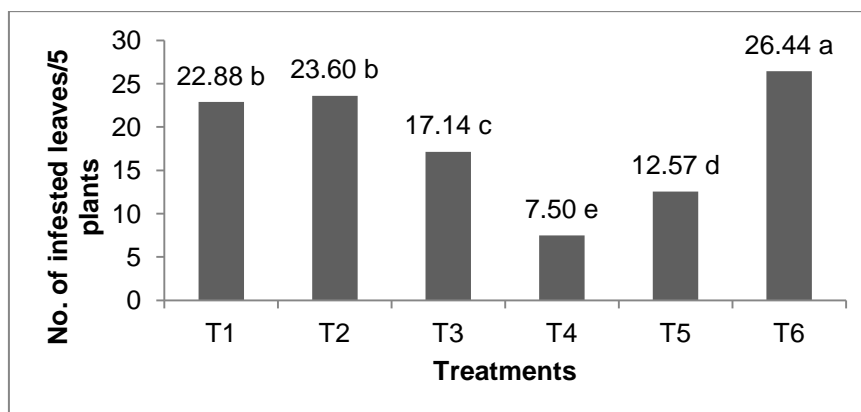


Fig. 2. Incidence of aphid by number in cabbage field treated by different treatments
T₁ = Spinosad, T₂ = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃ = Spodolure, T₄ = Spodolure + Spinosad, T₅ = Spodolure + SNPV, T₆ = Control

3.1.3 Incidence of cabbage semi-looper

The semi-looper only at its larval stage attacked cabbage leaves and damage caused by feeding leaf lamina in the form of irregular hole. Significant variation was observed on Semi-looper in number among the treatments (Fig. 3). Results revealed that the lowest number of Semi-looper (0.33) was found from T₄ (Spodolure + Spinosad) treatment whereas the highest number of Semi-looper (4.36) was found from control treatment T₆. Under treated plot, the highest number of Semi-looper (2.50) was found from T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) which was statistically identical with T₁ (Spinosad) and T₃ (Spodolure). This result was supported by Iqbal et al. 2015 [21].

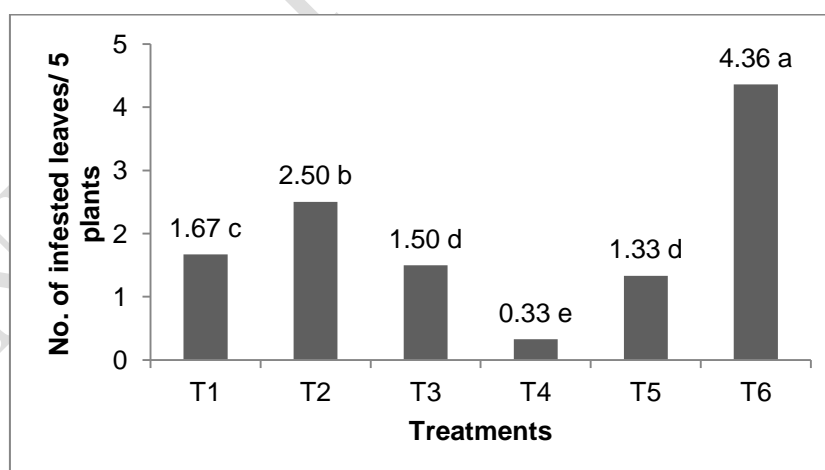


Fig.3. Incidence of semi-looper by number in cabbage field treated by different treatments
T₁ = Spinosad, T₂ = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃ = Spodolure, T₄ = Spodolure + Spinosad, T₅ = Spodolure + SNPV, T₆ = Control

3.1.4 Incidence of cabbage diamondback moth

The diamond back moth only at its larval stage attacked cabbage leaves and damage caused by upper epidermis of leaf in the form of irregular hole and net like appearance. Significant variation was observed on Diamondback moth in number among the treatments (Fig. 4). Results revealed that the

lowest number of Diamondback moth (1.33) was found from T₄ (Spodolure + Spinosad) treatment whereas the highest number of Diamondback moth (6.33) was found from control treatment T₆. Under treated plot, the highest number of Diamondback moth (4.00) was found from T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus). Goud *et al.* reported the similar result in diamondback moth incidence in 2006 [22].

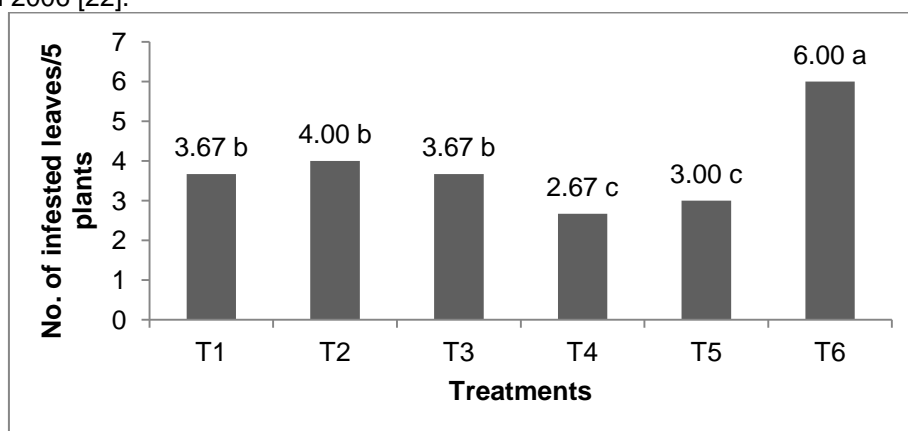


Fig.4. Incidence of diamondback moth by number in cabbage field treated by different treatments

T₁ = Spinosad, T₂ = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃ = Spodolure, T₄ = Spodolure + Spinosad, T₅ = Spodolure + SNPV, T₆ = Control

3.1.5 Incidence of cabbage tobacco caterpillar

The tobacco caterpillar only at its larval stage attacked cabbage leaves and head, and damage caused by voracious feeding of upper epidermis of leaf and head in the form of regular hole. Significant variation was observed on Tobacco cutworm in number among the treatments (Fig. 5). Results revealed that the lowest number of Tobacco cutworm (0.33) was found from T₄ (Spodolure + Spinosad) treatment whereas the highest number of Tobacco cutworm (5.28) was found from control treatment T₆. Under treated plot, the highest number of Tobacco cutworm (3.00) was found from T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) which was statistically identical with T₁ (Spinosad). More or less similar result was obtained by Reddy *et al* in 2017 [23].

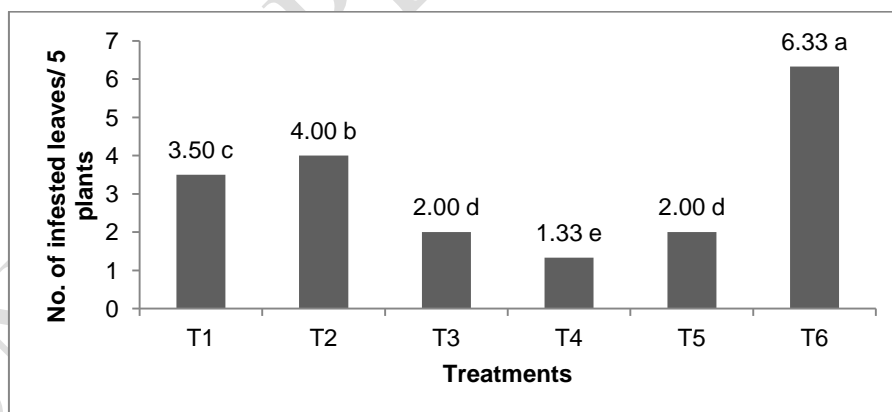


Fig.5. Incidence of cutworm by number in cabbage field treated by different treatments

T₁ = Spinosad, T₂ = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃ = Spodolure, T₄ = Spodolure + Spinosad, T₅ = Spodolure + SNPV, T₆ = Control

3.2 Incidence of natural enemies

3.2.1 Incidence of lady bird beetle

Significant variation was observed on lady bird beetle in number among the treatments (Fig. 6). Results revealed that the highest number of lady bird beetle (8.00) was found from T₄ (Spodolure + Spinosad) treatment whereas the lowest number of lady bird beetle (6.50) was found from control treatment T₆. Under the treated plot, the lowest number of lady bird beetle (6.75) was found from T₂

(SNPV; *Spodoptera litura* nuclear polyhedrosis virus) which was statistically identical with T₁ (Spinosad).

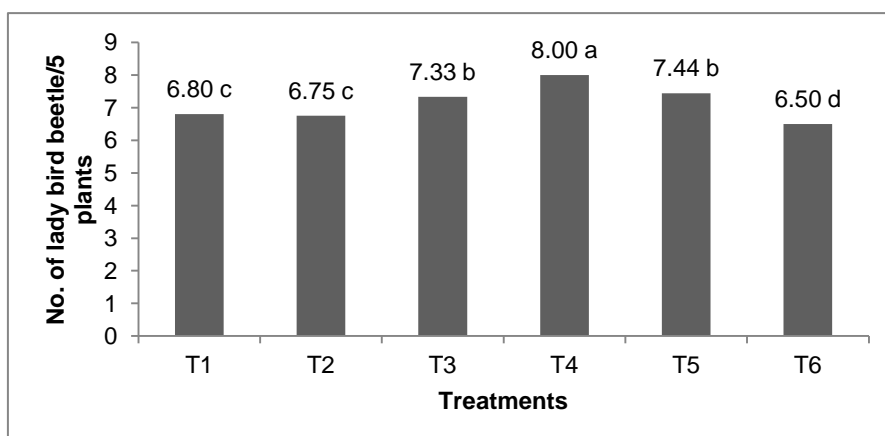


Fig.6. Incidence of lady bird beetle per plant in cabbage field treated by different treatments
T₁ = Spinosad, T₂ = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃ = Spodolure, T₄ = Spodolure + Spinosad, T₅ = Spodolure + SNPV, T₆ = Control

3.2.2 Incidence of spider

Significant variation was observed on spider in number among the treatments (Fig. 7). Results revealed that the highest number of spider (8.60) was found from T₄ (Spodolure + Spinosad) treatment whereas the lowest number of spider (6.80) was found from control treatment T₆. Under treated plot, the lowest number of spider (7.48) was found from T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) which was statistically identical with T₁ (Spinosad).

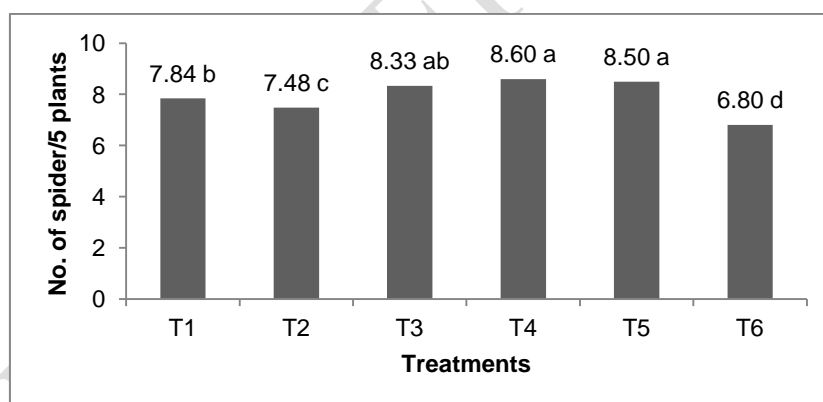


Fig. 7. Incidence of spider per plant in cabbage field treated by different treatments
T₁ = Spinosad, T₂ = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃ = Spodolure, T₄ = Spodolure + Spinosad, T₅ = Spodolure + SNPV, T₆ = Control

3.3 Performance of management practices

3.3.1 Performance regarding healthy plants number

Different treatments on percent (%) number of healthy plants showed significant variation at different days of crop duration (Table 1). Results indicated that the highest percent (%) number of healthy plants (100, 97.22, 94.44, 93.06 and 91.67% at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T₄ (Spodolure + Spinosad) treatment the lowest percent (%) number of healthy plants (90.28, 79.17, 69.44, 59.72 and 52.78% at 30, 50, 70, 90 DAT and at harvest, respectively) was found in control treatment T₆. But under treated plants the lowest percent (%) number of healthy plants (91.67, 84.72, 77.7, 73.61 and 70.83% at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) treatment which was statistically identical with T₁ (Spinosad) at the time of harvest.

Table 1. Effect of bio-pesticides on percent (%) number of healthy plants plot⁻¹ in cabbage field at different DAT

Treatments	Percent (%) number of healthy plants				
	30 DAT	50 DAT	70 DAT	90 DAT	At harvest
T ₁	93.06 bc	86.11 c	79.17 c	76.39 cd	73.61 d
T ₂	91.67 c	84.72 c	77.78 c	73.61 d	70.83 d
T ₃	94.44 bc	87.50 bc	81.94 c	79.17 c	77.78 c
T ₄	100.00 a	97.22 a	94.44 a	93.06 a	91.67 a
T ₅	97.22 ab	90.28 b	87.50 b	86.11 b	81.94 b
T ₆	90.28 c	79.17 d	69.44 d	59.72 e	52.78 e
LSD	0.76	0.73	0.79	0.63	0.72
CV(%)	4.97	7.07	6.52	9.57	8.98

In a column, means followed by same letter(s) do not differ significantly at 5% level by LSD DAT= Days After Transplanting, T₁ = Spinosad, T₂ = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃ = Spodolure, T₄ = Spodolure + Spinosad, T₅ = Spodolure + SNPV, T₆ = Control

3.3.2 Performance regarding infested plants number

Different treatments on percent (%) number of infested plants showed significant variation at different days of crop duration (Table 2). Results indicated that the lowest percent (%) number of infested plants (0, 2.78, 5.56, 6.94 and 8.33% at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T₄ (Spodolure + Spinosad) treatment the highest percent (%) number of infested plants (9.72, 20.83, 30.56, 40.28 and 47.22% at 30, 50, 70, 90 DAT and at harvest, respectively) was found in control treatment T₆. Under treated plants the highest percent (%) number of infested plants (8.33, 15.28, 22.22, 26.39 and 29.17% at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) treatment which was statistically identical with T₁ (Spinosad) at the time of harvest.

Table 2. Effect of bio-pesticides on percent (%) number of infested plants plot⁻¹ in cabbage field at different DAT

Treatments	Percent (%) number of infested plants				
	30 DAT	50 DAT	70 DAT	90 DAT	At harvest
T ₁	6.94 bc	13.89 b	20.83 b	23.61 bc	26.39 b
T ₂	8.33 ab	15.28 b	22.22 b	26.39 b	29.17 b
T ₃	5.56 c	12.50 bc	18.06 b	20.83 c	22.22 c
T ₄	0.00 e	2.78 d	5.56 d	6.94 e	8.33 e
T ₅	2.78 d	9.72 c	12.50 c	13.89d	18.06 d
T ₆	9.72 a	20.83 a	30.56 a	40.28 a	47.22 a
LSD	0.36	0.73	0.79	0.63	0.72
CV(%)	8.55	6.47	9.93	10.57	7.37

In a column, means followed by same letter(s) do not differ significantly at 5% level by LSD DAT= Days After Transplanting T₁ = Spinosad, T₂ = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃ = Spodolure, T₄ = Spodolure + Spinosad, T₅ = Spodolure + SNPV, T₆ = Control

3.3.3 Performance regarding healthy leaves plant⁻¹

At 30 DAT, no significant variation was found on number of healthy leaves plant⁻¹ (Table 3). But at 50, 70, 90 DAT and at harvest, significant variation was found due to different management practices against insect pest of cabbage (Table 4). Results revealed that the highest number of healthy leaves plant⁻¹ (14.36, 18.99, 20.70, 19.88 and 17.35 at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T₄ (Spodolure + Spinosad) treatment. The lowest number of healthy leaves plant⁻¹ (13.48, 14.90, 15.40, 14.63 and 12.68 at 30, 50, 70, 90 DAT and at harvest, respectively) was found in control treatment T₆. But under treated plants the lowest number of healthy leaves plant⁻¹ (13.85, 16.05, 16.85, 16.13 and 14.23 at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) treatment.

Table 3. Effect of bio-pesticides on number of healthy leaves plant⁻¹ of cabbage field at different DAT

Treatments	Number of healthy leaves plant ⁻¹
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	30 DAT	50 DAT	70 DAT	90 DAT	At harvest
T ₁	13.73	16.48 d	17.58 d	17.04 d	14.98 c
T ₂	13.85	16.05 d	16.85 e	16.13 e	14.23 d
T ₃	13.55	17.17 c	18.35 c	17.92 c	15.43 c
T ₄	14.36	18.99 a	20.70 a	19.88 a	17.35 a
T ₅	14.25	18.10 b	19.33 b	18.90 b	16.27 b
T ₆	13.48	14.90 e	15.40 f	14.63 f	12.68 e
LSD	1.72 ^{NS}	0.63	0.53	0.57	0.58
CV(%)	3.98	8.45	6.93	7.18	9.54

In a column, means followed by same letter(s) do not differ significantly at 5% level by LSD DAT= Days After Transplanting T₁ = Spinosad, T₂ = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃ = Spodolure, T₄ = Spodolure + Spinosad, T₅ = Spodolure + SNPV, T₆ = Control

3.3.4 Performance regarding infested leaves plant⁻¹

At 30, 50, 70, 90 DAT and at harvest, significant variation was found number of infested leaves plant⁻¹ due to different management practices against insect pest of cabbage (Table 4). Results showed that the lowest number of infested leaves plant⁻¹ (0.88, 1.05, 1.70, 2.18 and 2.63 at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T₄ (Spodolure + Spinosad) treatment. the highest number of infested leaves plant⁻¹ (3.43, 4.10, 4.63, 5.38 and 6.38 at 30, 50, 70, 90 DAT and at harvest, respectively) was found in control treatment T₆. But under treated plants the highest number of infested leaves plant⁻¹ (2.80, 3.25, 3.50, 4.25 and 4.75 at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) treatment.

Table 4. Management of major insect pest by bio-pesticides on number of infested leaves plant⁻¹ of cabbage

Treatments	Number of infested leaves plant ⁻¹				
	30 DAT	50 DAT	70 DAT	90 DAT	At harvest
T ₁	2.40 bc	2.75 bc	3.05 bc	3.50 c	3.88 c
T ₂	2.80 ab	3.25 b	3.50 b	4.25 b	4.75 b
T ₃	1.80 cd	2.43 cd	2.87 cd	3.25 cd	3.63 cd
T ₄	0.88 e	1.05 e	1.70 e	2.18 e	2.63 e
T ₅	1.55 de	2.03 d	2.38 d	2.75 d	3.25 d
T ₆	3.43 a	4.10 a	4.63 a	5.38 a	6.38 a
LSD	0.75	0.62	0.61	0.56	0.46
CV(%)	4.41	7.84	8.25	10.48	7.53

In a column, means followed by same letter(s) do not differ significantly at 5% level by LSD DAT= Days After Transplanting T₁ = Spinosad, T₂ = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃ = Spodolure, T₄ = Spodolure + Spinosad, T₅ = Spodolure + SNPV, T₆ = Control

3.4 Management of major insect regarding yield performance

3.4.1 Weight of healthy cabbage head plant⁻¹

Different treatments on weight of healthy cabbage head plant⁻¹ showed significant variation (Table 5). Results indicated that the highest healthy cabbage head plant⁻¹ (1.20 kg) was found in T₄ (Spodolure + Spinosad) treatment. the lowest healthy cabbage head plant⁻¹ (0.88 kg) was found in control treatment T₆. But under treated plants the lowest healthy cabbage head plant⁻¹ (0.97 kg) was found in T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) treatment which was statistically similar with T₁ (Spinosad).

In terms of % increase of healthy head weight plant⁻¹ over control, the highest % increase (36.36%) was found in T₄ (Spodolure + Spinosad) whereas the lowest % increase (10.23%) was found in T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) treatment. This result was supported by Dey et al. [24].

3.4.2 Weight of infested cabbage head plant⁻¹

Different treatments on weight of infested cabbage head plant⁻¹ showed significant influence (Table 5). Results indicated that the lowest infested cabbage head plant⁻¹ (0.52 kg) was found in T₄ (Spodolure + Spinosad) treatment which was significantly different from other treatment. The highest infested cabbage head plant⁻¹ (0.92 kg) was found in control treatment T₆ whereas under treated plants the highest infested cabbage head plant⁻¹ (0.66 kg) was found in T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) treatment.

In terms of % decrease of infested head weight plant⁻¹ over control, the highest % decrease (43.48%) was found in T₄ (Spodolure + Spinosad) followed by T₅ (Spodolure + SNPV) whereas the lowest % decrease (28.26) was found in T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) treatment.

3.4.3 Marketable cabbage head plot⁻¹

Different treatments on marketable cabbage head plot⁻¹ (kg) showed significant variation (Table 5). Results indicated that the highest marketable cabbage head plot⁻¹ (19.48 kg) was found in T₄ (Spodolure + Spinosad) treatment. The lowest marketable cabbage head plot⁻¹ (8.30 kg) was found in control treatment T₆. but under treated plants the lowest marketable cabbage head plot⁻¹ (12.34 kg) was found in T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) treatment.

3.4.4 Marketable cabbage head ha⁻¹

Different treatments on marketable cabbage head ha⁻¹ (kg) showed significant variation (Table 5). Results indicated that the highest marketable cabbage head ha⁻¹ (45.08 t) was found in T₄ (Spodolure + Spinosad) treatment whereas the lowest marketable cabbage head ha⁻¹ (19.24 t) was found in control treatment T₆. but under treated plants the lowest marketable cabbage head ha⁻¹ (28.57 t) was found in T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) treatment. Similar trend of yield was found by other authors using chemical insecticides [25]. As using biopesticides is better and safer than chemical insecticides, then is wise to use the biopesticides.

Table 5. Effect of bio-pesticides on yield and yield contributing characters of cabbage

Treatments	Yield parameters					
	Wt.of healthy cabbage head plant ⁻¹ (kg)	% increase of healthy head plant ⁻¹ over control	Wt. of infested cabbage head plant ⁻¹ (kg)	% decrease of infested head plant ⁻¹ over control	Cabbage yield plot ⁻¹ (Marketabl) (kg)	Cabbage yield ha ⁻¹ (Marketabl) (t)
T ₁	1.03 bc	17.05	0.80 b	13.04	13.68 d	31.65 d
T ₂	0.97 cd	10.23	0.66 c	28.26	12.34 e	28.57 e
T ₃	1.10 ab	25.00	0.60 d	34.78	15.35 c	35.54 c
T ₄	1.20 a	36.36	0.52 e	43.48	19.48 a	45.09 a
T ₅	1.18 a	17.05	0.55 e	40.22	17.38 b	40.23 b
T ₆	0.88 d	--	0.92 a	--	8.31 f	19.24 f
LSD	0.12	--	0.05	--	1.29	2.99
CV(%)	7.49	--	8.94	--	5.94	6.94

In a column, means followed by same letter(s) do not differ significantly at 5% level by LSD, T₁ = Spinosad, T₂ = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T₃ = Spodolure, T₄ = Spodolure + Spinosad, T₅ = Spodolure + SNPV, T₆ = Control

CONCLUSION

The result of the current analysis suggests that among the different treatments T₄ comprised of Spodolure trap along with Spinosad spray gave the highest performance where the lowest performance was obtained by control treatment. On the other hand, the lowest performance among the treated plots was achieved by T₂ (SNPV; *Spodoptera litura* nuclear polyhedrosis virus).

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